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the line of outcrop of the McCann sandstone, from Caldwell to Redrock, a distance of fifty miles. The area occupies the greater part of Kay and a small part of Noble and Grant counties.

The work already done on the geology of the region is but fragmentary. The data collected on one or two reconnaissance trips, made at various times, constitute almost all of the available information at present. Although no fossils have been found in these formations in Oklahoma, it is now known that the horizons immediately sub- and superjacent contain organic remains; and it is by no means improbable that research will reveal fossils in these beds. The lithological character of the rock is, in some cases, of especial significance. It may often be observed that a shale bed becomes distinctly arenaceous to the south, so much so that in many instances the lithology changes entirely, and the rock will become a true sandstone. Further south in the territory there are several hundred feet of gray and brown sandstones and shales below the Harper, for which the name Stillwater sandstone has been proposed. It may eventually be proven that the Stillwater is but a southern continuation of the Sumner. While no attempt has been made to correlate these rocks with the Texas beds, it may not be considered improbable that future investigation will demonstrate that the Wichita beds south of the Arbuckle mountains are contemporaneous in time with the Salt Fork or lower division of the Red Beds in Kansas and Oklahoma.

The investigations of the Oklahoma Geological Survey during the past summer revealed the fact that the ledges of limestone and shale that form the Flint hills thin out to the south and disappear before reaching the middle of the territory. The culmination of these hills is evidently in eastern Cowley county. Even within Kansas, however, ledges of sandstone appear near the top of the Flint hills. These sandstones become more pronounced to the south, and in the southern part of the Osage nation occupy perhaps half of the thickness of the formations. In eastern Payne county, Oklahoma, and the northwestern part of the Creek country only a few comparatively thin ledges of limestone remain, and in Lincoln county the last of these disappears. Along the line of the North Canadian, from Oklahoma City to Okmulgee, no limestone appears. In this region only sandstones and shales occur.

From what has preceded, it will appear that south of the Kansas line the Carboniferous sandstones from the east and the Red Beds from the west gradually approach each other. At the same time, the Flint hills and the Sumner division become less and less pronounced, until, in central Oklahoma, both of these divisions have disappeared and sandstones and shales occupy the entire area.

THE OKLAHOMA SALT PLAINS.

BY C. N. GOULD, NORMAN, OKLA.

Read before the Academy December 28, 1900.

There are in the Permian rocks of Kansas and Oklahoma two distinctively saliferous horizons. To these Cragin, in his article, "The Permian System in Kansas,"[1] gave the name Geuda salt measures and Salt Plain measures. Prosser's name, Marion,[2] however, had priority over the term Geuda salt measures, and is now in general use.

The Marion formation lies immediately above the Flint hills. It consists of from 400 to 500 feet of saliferous and gypsiferous shales and clays, with a considerable amount of fossiliferous limestone in the lower part. The salt obtained at Hutchinson, Lyons, Kanopolis, and other Kansas points is from this formation. Along the eastern outcrop of this saliferous horizon, in Cowley, Sumner, Sedgwick, Butler, and Harvey counties, Kansas, the water is often distinctly salty. In the vicinity of Geuda Springs there some small salt plains, but in comparison with those referred to later in this article they are scarcely worthy the name.

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[1] Colorado College Studies, vol. VI, p. 9.

[2] Journal of Geology, vol. III, No. 7, p. 786.

The Marion is succeeded above by the Wellington, and this in turn by the Harper.[3] These two formations, which approximate 1100 feet in thickness, are composed throughout of variously colored clays, shales, and sandstones. In the Wellington the clays and shales are prevailingly blue, green, or gray. In the Harper the color is normally a brick red. Throughout both formations there is a great quantity of mineral salts. Of these, gypsum and common salt predominate, although magnesia, borax, dolomite, and others are not infrequent. These minerals seem to increase in amount toward the upper part of the formations. The salt particularly appears to reach its culmination in the Salt Plain measures which lie upon the Harper.

Stratigraphically, the Salt Plain is the most unsatisfactory formation in the Kansas-Oklahoma Red Beds. Indeed, it is still an open question whether it would not be wise to either assign it to subformation rank under the Harper or drop it altogether from the nomenclature of the series. In discussing the formation, Professor Cragin himself says: "The Salt Plain measures force themselves upon us as a very pronounced and, if interrupted, persistently recurring saline horizon."[4] It is not doubted that the saliferous sandstones and shales are of frequent occurrence in the middle Kansas-Oklahoma Red Beds. Nor is it questioned that the culmination of these measures is below the Gypsum hills. But that all or even a greater part of these measures are confined to a definite horizon remains to be proven. In fact, it has been demonstrated that the largest salt plain in Oklahoma—the Salt Fork plain—is located near the middle of the Harper.

The Salt Plain formation, as described by Cragin, outcrops along a line skirting the east flank of the Gypsum hills, from Barber county, Kansas, as far south as the Canadian river. According to his last classification, it lies between the Harper and the Glass Mountain formations;[5] the Harper comprising the large level area in southern Kansas and central Oklahoma, and the Glass Mountain including the eastern slope of the Gypsum hills. Of the four large salt plains in Oklahoma, at least three may be definitely assigned to this horizon. These are the Big Salt plain, and Little Salt plain of the Cimarron, situated in the northern part of Woodward county, and the Salt Creek plain, in northern Blaine county. The latter is located near the head of Salt creek, a tributary of the Cimarron. In every case these plains are situated in cañons at the base of the Gypsum hills, and from 150 to 200 feet below the heavy ledges of gypsum which cap these hills.

Perhaps the most noted of the salt plains, from the standpoint of a historian, is the Big Salt plain of the Cimarron. The first white man to visit this place was probably Coronado, in his journey across the plains in search of the seven cities of Cibola. In regard to this event, Mr. J. R. Mead says: "The route or trail of Coronado, in his famous expedition from the Pueblos of New Mexico across the prairies of Kansas to the populous tribes of the Missouri, will ever remain an open question. The only point that we can locate with reasonable certainty is the salt plain of the Cimarron, just within the Kansas line—the only place where rock salt can be obtained on the surface in all the plains country. This salt was known and used by the Indians, and was an article of trade from the Gulf to the British line, and this locality was a well-known geographical point, from which distances were reckoned."[6] The presence of a dozen or more trails, now nearly obsolete, radiating from the plain like spokes of a wheel, bears testimony to the fact that this place was long used as a source of supply of salt to the various forts and settlements of the surrounding regions. Indeed, it is but a few years since salt from this plain was hauled for hundreds of miles in all directions, and not until the time of the discovery of extensive beds in central Kansas did this industry wane.

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[3] Colorado College Studies, vol. VI, pp. 16, 18.

[4] American Geologist, vol. XIX, No. 5, May, 1897, p. 352.

[5] Ibid., p. 363.

The Big Salt plain proper extends for eight miles or more along the Cimarron river. In width it varies from half a mile to two miles. On the south bank the bluffs of red shale and sandstone capped with gypsum rise directly from the edge of the plain to the height of 100 feet or more. North of the plain these bluffs are not so steep, and are at a distance of a half mile or more from the plain. Even here, however, the sinuous white line of gypsum may be traced along the tops of the bluffs as far as the eye can reach. In other words, the plain lies in the broad cañon of the Cimarron, enclosed on both sides by gypsum-capped bluffs of red shale.

The plain is flat and as level as a floor, except for a few meandering channels which, in wet weather, contain a small stream, but are ordinarily dry, After a rain it will sometimes happen that a stream of considerable volume flows over the plain, but during the summer months nearly all the water either evaporates or sinks into the sand. In places where a small stream still runs down the channel, the water is often so salty that a thin crust of crystal white salt forms on the surface, resembling nothing so much as a sheet of ice across a small stream in winter. The entire plain is covered with a thin incrustation of snow-white salt crystals. In most places this incrustation is not to exceed an eighth of an inch thick, but it reflects the sunlight and blinds the eye like a snow field. Especially if the wind be blowing the small particles of salt, a walk across the plain makes the eyes smart and burn in a manner not easily forgotten.

In a large cove on the south side of the plains proper, there are a number of salt springs which boil up out of the flat surface of the plain. The water is crystal clear, and it sometimes requires more than ocular proof to convince one that it contains nearly fifty per cent. of salt. There are scores, perhaps hundreds, of these springs on an area a few acres in extent. Some of them flow streams as large as a man's arm; others are much weaker. In all cases their presence is marked by a conspicuous white incrustation of salt, which forms around the spring and along the sides of the little stream that flows from it. Particles of grass or weeds blown into these springs or streams soon become covered with white salt crystals. These strings of crystals are often an inch or more in diameter and look like rock candy. In places the incrustations around the springs are so thick that the salt may be scraped up and hauled away. This is the source of the so-called rock salt of the plain.

The Little Salt plain is located a few miles further up the Cimarron, just on the border of Kansas. It does not differ materially from the plain just described, except that it is much smaller and the bluffs on either side of the river are neither so high nor precipitous.

Besides the two plains of the Cimarron, the Salt Creek plain, in northern Blaine county, also belongs to the Salt Plain formation. Like the others, it is located in a cañon at the foot of the Gypsum hills. This plain is much smaller than the Big Salt plain just described. It is not to exceed a quarter of a mile wide in the widest place, and for the greater part of its course is not more than 100 yards in width. It is perhaps three miles long.

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[6] Kans. Hist. Coll., vol. V, 1896, p. 89.

The region of Salt creek is one of the most picturesque spots in Oklahoma. The upland covered with jack-oak-bearing Tertiary sands breaks off into precipitous cliffs and cañons 200 or more feet deep. The slopes of these cañons are composed of the brick-red shales of the Glass Mountain formation, and are capped by the massive white ledges of gypsum and dolomite of the Cave Creek formation. Dozens of narrow cañons with cedar-covered slopes radiate outward from Salt creek and its tributary, Bitter creek. It is in the head of the main Salt Creek cañon that the springs which supply the plain are found. A fifteen-foot ledge of red-and-blue-mottled, cross-bedded sandstone outcrops in the heads of several branches of the main cañon. It is from this saliferous sandstone that the springs issue. Along the bottom of the cañon salt incrustations cover a narrow strip 100 yards or more in width. A mile below the springs the cañon widens out and the creek leaves the wall of hills and enters the flat country. The salt plain spreads out, and in one place becomes perhaps a quarter of a mile wide. A mile or so down the creek it is joined by other streams and soon loses its individuality.

From the standpoint of economic importance the Salt Creek plain exceeds all others in the territory at the present time. A number of primitive salt plants are located along the edge of the plain. The methods employed in the evaporation of salt are extremely simple. A well is dug in the soft sand of the plain, and the water pumped by hand into vats and evaporated by boiling. It is stated that three buckets of brine make one of salt. The capacity of the best plant running at the present time is approximately 2000 pounds per day. The salt is hauled in wagons to supply local trade. The demand is said to exceed the supply for a part of the year. There is enough brine in this locality alone to make a number of car-loads of salt a day.

The largest salt plain in Oklahoma, however, is not near the Gypsum hills, nor even in the region of outcrops of the Salt Plain formation. It is in the northeastern part of Woods county. The nearest point of the Gypsum hills is at least thirty miles from this plain. As stated above, the geological horizon is well down in the Harper, perhaps 200 feet below the top of this formation. This plain is the only one in the territory that is not located on the waters of the Cimarron. It is usually known as the Salt Fork plain, from its position on the Salt Fork of the Arkansas. The plain occupies an area approximately eight miles north and south and six miles east and west. The greater part of the plain lies south of the river. It is as level as a floor and absolutely bare of vegetation. Only here and there does an occasional bit of driftwood break the dreary monotony. On a warm day a view across the snow-white plain stretching away into the seemingly infinite distance will often reveal a mirage shimmering along the horizon. Trees, watercourses and cultivated fields stand out in bold relief, and so natural do they appear that one may sometimes be tempted to believe that they are more than mere optical illusions.